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THE RELATIONSHIP OF NORTHERN GOSHAWK NEST SITE LOCATIONS TO RIPARIAN AREAS IN THE CENTENNIAL MOUNTAINS, IDAHO TARGHEE NATIONAL FOREST

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ABSTRACT

In 1993 we surveyed a large (84.7 km^2) relatively pristine forest area for nesting goshawks in the Centennial Mountains on the Targhee National Forest (TNF) in northeastern Idaho. Our main objective was to determine if goshawks disproportionately select nest sites near riparian areas and permanent water sources. In addition, we wanted to 1) describe more specifically riparian habitats associated with goshawk nest sites 2) determine density of nest sites in undisturbed forest habitat, and 3) evaluate potential bias of our existing goshawk database that consists of nest sites found over the past decade. Using ARC/INFO GIS coverages, we measured area and percent cover types both within the entire study area and within a defined near-riparian zone of 250 m surrounding permanent water sources. The near-riparian zone included 25% of the study area and 27% of available mature forest habitat. We used broadcast vocalizations at over 575 calling stations to locate nesting goshawks. Two territories were found located 7.5 km apart containing two occupied and five associated alternate nests. All nests found fell within our defined near-riparian zone; mean distance to water was 152 m. Closest water sources to nests were first order streams with grass/forb riparian habitat surrounded by mature conifers.

Density of goshawk nesting pairs was calculated to be 1 pair per 30.2 km^2 of suitable habitat. Nests were found in large contiguous patches of mature Douglas fir (*Pseudotsuga menziesii*) habitat. We compared habitat characteristics of occupied study area nests (n=2) to other Douglas fir nest sites on the forest (n=37) using multiresponse permutation statistical procedures (MRPP). Study area nests were located significantly farther from forest edge compared to previously identified sites but nest tree, nest site, and topographic characteristics were similar. Considering all nest territories (n=27), median distance to permanent water measured 267 m. Comparing nest sites to random sites (n=27) selected from within estimated home range areas, distance to water did not differ significantly (MRPP, p=0.462). First order streams were the most common type of water source associated with nest sites on the Forest. Summarizing other studies in the western United States, distance to water from goshawk nests averaged 183 m (101 SE). To manage goshawk nesting territories within timber sale areas, we recommend that all permanent water sources be identified and surrounding habitat surveyed for occupied and alternate nest sites. Buffers, including both riparian and upland areas, with mature trees and high canopy cover should be maintained in Douglas fir habitat to provide adequate nesting and foraging habitat for resident goshawks.

INTRODUCTION

The importance of riparian and wetland habitats for wildlife in the western United States and concern over loss and degradation of such habitats have received increasing attention over the last decade (Ohmart and Anderson 1986, Lee et al. 1989, Chaney et al. 1990, Krueper 1993, Ohmart 1994). Studies of wetland trends indicate that during the past century total wetland/riparian area in the West has declined an average 70% (Lee 1989). Ohmart (1994) estimated that 95% of western riparian habitats have been altered, degraded or destroyed over the past 100 years. Much attention has focused on wildlife use of the most conspicuous riparian habitats along major rivers and streams, especially those found in the Southwest (Johnson and Lowe 1985). Studies of wildlife use of riparian zones dominated by conifer species are much less common (Swanson et al. 1982).

Riparian zones, due to their high primary productivity and structural complexity, provide essential breeding, foraging, and resting areas for many terrestrial wildlife species including a number of raptor species (Cross 1985, Anthony et al. 1987, Lee 1989, Doyle 1990, Krueper 1993). Diurnal raptor species most often associated with riparian and wetland habitats in western North America include the bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), red-shouldered hawk (*Buteo lineatus*), northern harrier (*Circus cyaneus*) and the three accipiters: northern goshawk (*Accipiter gentilis*), Cooper's hawk (*Accipiter cooperii*), and sharp-shinned hawk (*Accipiter striatus*) (Johnsgard 1990).

A number of studies on the northern goshawk have reported that nests are often located near water sources (Bartelt 1974, Hennessy 1978, Shuster 1980, Reynolds et al. 1982, Hall 1984, Speiser and Bosakowski 1987, Hargis et al. 1994). The presence of water close to nest sites could be advantageous for a number of reasons. Water would be available for drinking and bathing especially by the adult female who remains close

to the nest throughout the nesting period; preferred prey species may concentrate near water sources; and in dry climates or open canopy sites, frequent bathing might be used to control nest humidity (Crocker-Bedford and Chaney 1988, Palmer 1988, Marshall 1992).

Most studies on goshawk nesting habitat in the United States have focused primarily on describing and measuring the vegetative structure of nest sites. The relationship between nesting habitat and water sources has not been adequately determined. Only a few studies have described the type of water source or riparian habitat closest to nesting areas (Hall 1984, Speiser and Bosakowski 1987) and consequently, management recommendations are vague in regards to these features.

The breeding range of the northern goshawk in western North America extends from treeline in Alaska and northern Canada southward throughout the montane forests of the United States and into northern Mexico (Palmer 1988). Over the past decade, concern has developed that timber harvesting and resulting habitat loss in some areas may be causing declines in goshawk breeding populations (Reynolds et al. 1982, Herron et al. 1985, Bloom et al. 1986, Reynolds 1987, Crocker-Bedford 1990; Patla 1991; Reynolds et al. 1992).

Due to these concerns the USDA Forest Service Intermountain Region (FSIMR), which administers public lands in southern Idaho, western Wyoming, Nevada, and Utah, listed the goshawk as a "sensitive species" in 1991. Since an estimated 70% of potential nesting habitat for goshawks in Idaho is located on Forest Service lands where timber harvesting and other management activities occur, data on habitat use and population status are needed to develop adequate management guidelines (USDI 1991).

The most detailed goshawk management guidelines developed to date for the U.S. Forest Service Southwestern Region (Reynolds et al. 1992) state that goshawks often place nests near streams in older-aged, high canopy cover forests. Recommendations

call for designating three suitable and three replacement nest areas with "most" located on northerly aspects in mesic areas along drainages (Reynolds et al. 1992). The guidelines did not describe the types of drainages or riparian habitats which may be most suitable for nesting habitat. No specific recommendations were made for minimum or maximum distances between designated nest stands and water sources.

The FSIMR is currently reviewing and modifying Southwestern goshawk management guidelines to include forest types found in more northern areas (Ron Rodriguez, regional goshawk coordinator, Dixie National Forest, pers. comm). Very little specific data exist, however, on location of goshawk nests in relation to riparian habitats in the central and northern Rocky Mountain area.

Bartelt (1974) reported that 22 out of 24 goshawk nests in the Black Hills of South Dakota were found within 0.84 km of open water. Thirty-two goshawk nests in northern Utah occurred an average distance of 394 m from water (Hennessey 1978). In northern Colorado, 20 goshawk nest sites were found 10-450 m from water with most within 275 m. (Shuster 1980). Seventeen nests in northern Idaho and western Montana were located generally within 0.5 km of water (Hayward and Escano 1991). In the Centennial Mountains of northeastern Idaho, 1989-1992, we found 11 nest areas located an average distance of 359 m from water (range 52-1753 m; 147 SE) (Patla, unpublished data). Eliminating one extreme value, mean distance to water for the 10 remaining sites dropped to 220 m (54.8 SE). These studies, while indicating a trend for nests to be located close to water, were not set up to compare available versus used habitat and did not show actual selection by goshawks for sites close to water.

To determine if goshawks disproportionately select nest sites near riparian areas, we used broadcast vocalizations to survey a relatively undisturbed 85 km^2 area in the Centennial Mountains of northeastern Idaho for active goshawk nest sites. In addition to determining the importance of riparian areas in goshawk nest site selection, our objectives were: 1) to describe more specifically water sources and riparian habitats

located in goshawk nesting areas, 2) to obtain a better understanding of goshawk nest site density in undisturbed habitat, and 3) to evaluate potential bias of our existing goshawk nest site database for the Targhee National Forest which consists of nest sites found in a non-systematic manner over the past decade.

STUDY AREA

The study area encompassed rugged, forest-covered mountainous country on the south and east facing slopes of the Centennial Mountains on the Targhee National Forest (TNF) northwest of Kilgore, Idaho (Fig. 1, 2). This area was chosen because of its relatively undisturbed condition. It extends south from the Continental Divide (Idaho-Montana State border) to West Camas Road (#006), and in the east-west direction from East Camas Road (#026) and Spruce Creek to Pete Creek Road (#010). Elevation ranges from 1982 m to over 2744 m. Approximately 96 km of stream drainages are located within the study area; 44 km are classified as perennial (TNF GIS database). The interior of the study area is unroaded and contains less than 6.2 km of maintained trails (TNF GIS database).

The climate consists of relatively dry summers and cold, harsh winters with snow persisting at higher elevations from November through late April/late May. Annual precipitation between 1982-1992 averaged 74.4 cm at the Crab Creek weather station located south of the study area (Station #3428, Lat. 44 26 Long 112 00, 2091 m elevation, National Climatic Data Center). Monthly average precipitation ranged from a low in August of 3.74 cm to a March high of 9.30 cm. Snow depth in January, March and April averaged 51, 109, and 137 cm. respectively. Mean monthly temperatures (1962-1967) at Kilgore (Station #4908, Lat 44 24 Long 111 53, 1927 m elevation) ranged from 13 degrees C. in January to 58.9 degrees C in July.

The major habitat type found within the area is *Pseudotsuga menziesii/Calamagrostis rubescens* (PSME/CARU; Douglas fir/pinegrass) which occurs up to 2469 m (Steele et al. 1983). At higher elevations, stands of white-bark pine

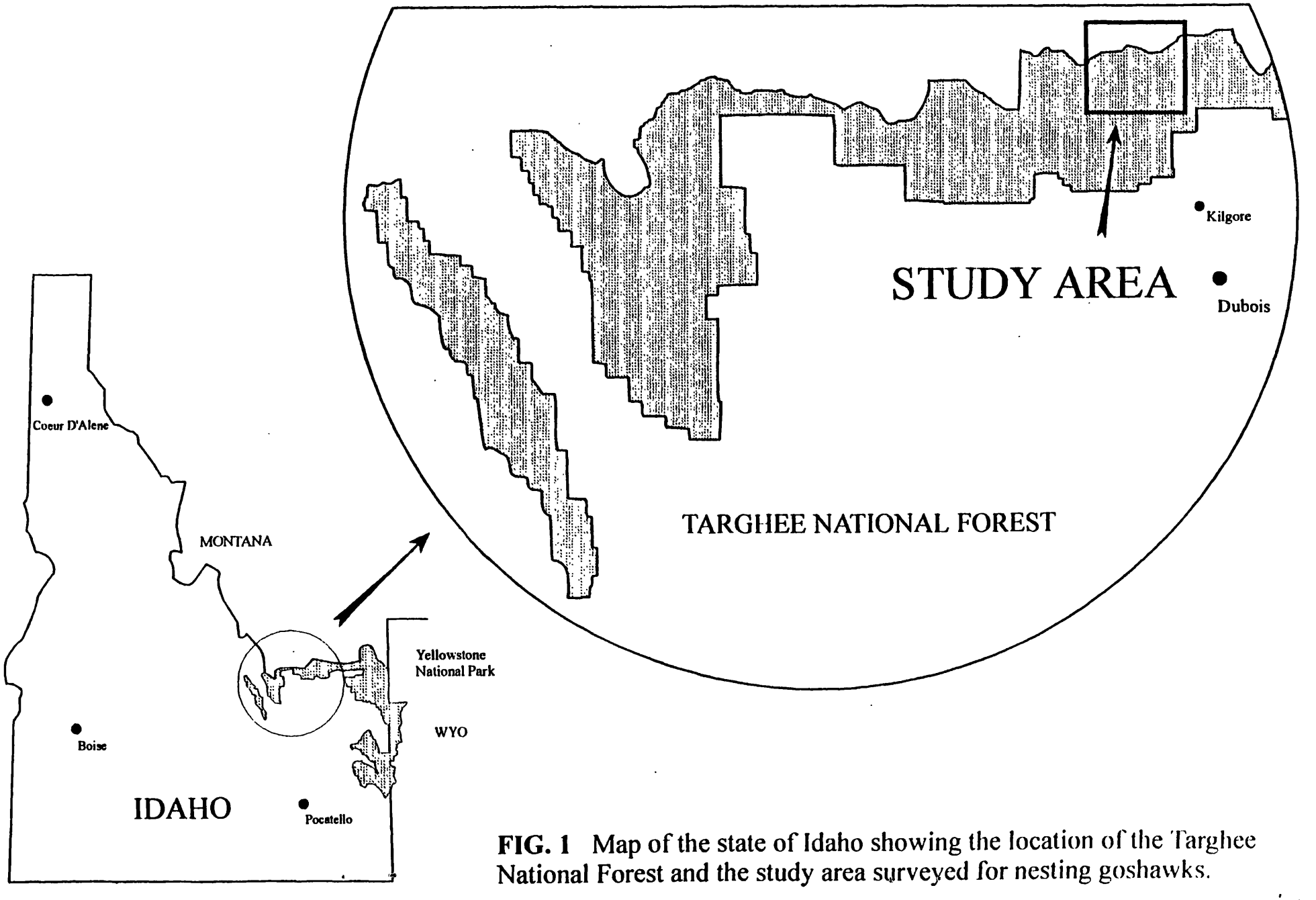

FIG. 1 Map of the state of Idaho showing the location of the Targhee National Forest and the study area surveyed for nesting goshawks.

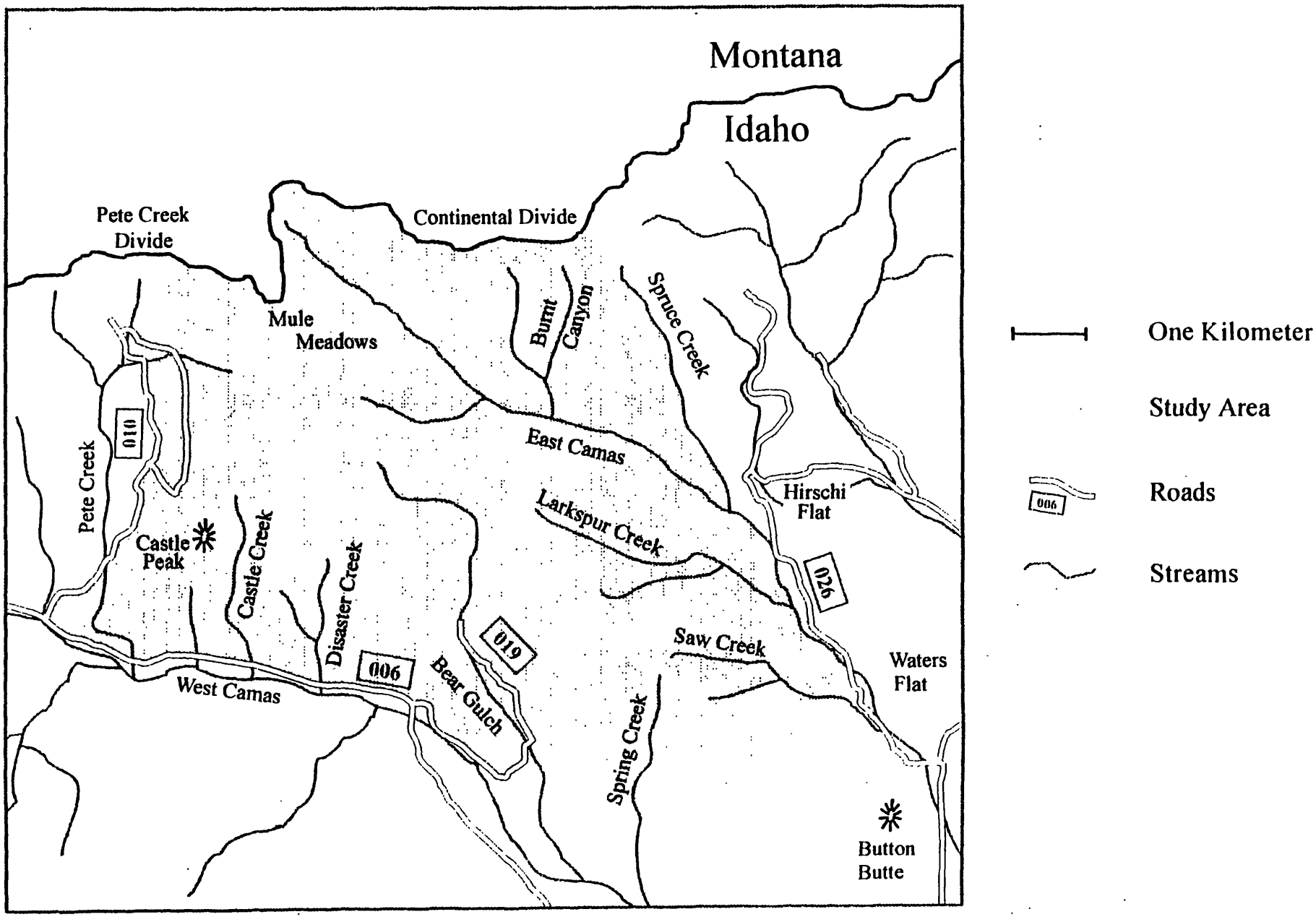

Fig. 2. Map of goshawk survey area (shaded area) showing major roads and streams, Centennial Mts., Targhee National Forest.

(*Pinus albicaulis*) and subalpine fir (*Abies lasiocarpa*) prevail. Other tree species found within the area include aspen (*Populus tremuloides*), lodgepole pine (*Pinus contorta*) and Engelmann spruce (*Picea engelmannii*). The most extensive forest habitat occurs below 2500 m. (8200 ft.); above this elevation forest stands are fragmented by natural meadow openings or steep rock cliffs and talus slopes.

At lower elevations outside the study area, agricultural fields and sagebrush (*Artemesia tridentata*) meadows are bisected by the major drainages of East and West Camas Creeks and Pete Creek. Willow (*Salix*, sp.) and aspen prevail along the stream courses. North of the study area in Montana, the forested north-facing slope of the Centennial Mountains drops down to the Centennial Valley. The status of the goshawk population on the north side of the Centennial Mountains remains largely unknown except for a few sight records of individual birds (Marco Restani, Utah State University; Dr. Jack Kirkley, Western Montana College, pers. comm.).

The study area encompasses one of the largest contiguous, unroaded, lower elevation sections remaining along the southside of the Centennial Mountains. Some timber harvesting and road building occurred previously in four separate locations along the periphery of the study area prior to 1993: Spruce Creek timber sale on the northeastern side (1985: 210 ha); Saw Creek sale on the southeastern (1983: 101 ha); Bear Gulch sale on the south (1984-86: 445 ha), and Pete Creek sale on the west (1985-87: 420 ha) In the Saw Creek timber sale area, some large diameter Douglas firs were harvested but a well developed canopy remains. In the other timber sale areas, a larger percentage of the overstory canopy was removed from harvest units leaving much more open stands (Kim Johnson, Wildlife Biologist, Dubois Ranger District, pers. comm.) The most extensive road building associated with timber sales occurred in the Pete Creek and Bear Gulch areas but locked gates prevent motorized use on many of these roads. None of the open roads extend into the interior of the defined study area.

Seven existing grazing allotments are at least partially contained within the survey area. In most years, grazing occurs between mid-June to mid-October. On the East Camas allotment, cattle grazing (150 cow/calf pairs) is restricted to a small area mostly on open sage meadows along the edge of the forest. More extensive grazing occurs within forest habitat along the slopes which drain into West Camas Creek east of Bear Gulch and west of Pete Creek (908 cow/calf pairs). In 1992, only one sheep allotment was in use (1000 ewe/lamb pairs) on the higher elevation slopes of East Camas Creek near Big Table Mountain on the Montana border. Three other sheep allotments were inactive.

No surveys for goshawk had been conducted prior to 1993 in the central portion of the study area. In 1991 fledged goshawks were found near Spring Creek in the southeastern corner of the study area during a visual survey of the proposed Saw Creek Timber Sale but no nest site was identified (K. Johnson, Dubois District Biologist, pers. comm.) In 1985 loggers found an alternate stick nest in the Pete Creek Timber Sale and left a small buffer around the tree but no other goshawk nests have been located in that area although goshawks have been sighted occasionally (Mary Maj, Dubois District, former Biologist, pers. comm; Patla, unpubl. data).

METHODS

SURVEY METHODS

We conducted surveys for goshawks within the study area using a slight modification of Kennedy and Stahlecker's (1993) broadcast survey method during the nesting and fledgling periods from June 17 through August 10, 1993. From mid-June to mid-July, we played the goshawk "alarm" call to elicit responses from nesting goshawks. From mid-July through early August we used the adult female "wail" call. This vocalization, given by the adult female during the nesting period when the male brings prey to the stand, often elicits responses from recently fledged young. In mid to

late August, we also played a few alarm calls after the wail call sequence as we have found that young goshawks often respond to this call as well. Taped calls were obtained from Sullivan Recording (Ashland, OR) which produced tapes originally recorded on the Klamath National Forest in northern California (Brian Woodbridge, Wildlife Biologist, Klamath National Forest, pers. comm.)

Based on dominant aspect and drainage patterns, the study area was divided into seven subsections on 7.5 min USGS quadrangle maps. Within each section, parallel transect lines were drawn 260 m apart, with orientation dependent upon topography and accessibility. Observers played goshawk vocalizations at stations every 300 m along these predetermined transect lines even if stations occurred in open meadow or harvest areas. Broadcast stations were staggered by 150 m on adjacent transect lines to achieve an estimated coverage of 90.6% of the survey area (Joy et al. 1994). We used a modified Radio Shack Power Horn (model 32-2030) attached to a Sony (Walkman model WMA53) portable cassette tape player which produced a call 100-100 db which was audible to the human ear at a minimum of 150-800 m depending on terrain and wind (Patla, pers. obs). Surveys were postponed or terminated on days with heavy rain or wind over 20 km/hr.

Upon arriving at a station, observers played the tape for 10 seconds while moving the megaphone in an arc from 270 degrees to 90 degrees while facing forward on the transect line. They then listened for one minute while visually scanning for goshawks flying in silently. The call was then played again for 10 seconds in each of the four cardinal directions, with a 30 second pause between each sequence. After scanning the area for another minute, they continued on to the next station. While moving between stations, observers were instructed to listen continually for vocalizations and look for nests, prey remains and feathers. They recorded all bird and mammal species sighted along transects.

For efficient utilization of available field time, observers followed a modified protocol to survey some fragmented forest stands in harvested areas located on the northwest and northeast edges of the survey area (Pete Creek Timber Sale and Spruce Creek Timber Sale), and in naturally fragmented habitat in the northern third of the area. Exploratory trips were first made into these areas to determine the condition of remaining mature timber stands (density and canopy cover) and to assess which stands contained trees of adequate size and structure to support goshawk nests. To be classified as suitable, stands had to have over 30% canopy cover and contain trees at least 15 m in height. When observers returned to survey areas, they determined the placement of transect lines after visually inspecting suitable stands to make sure that broadcasts reached all identified nesting habitat. Calling stations were set every 150-250 m along these transects. No calling stations in these fragmented habitats were located in open meadow areas or on talus slopes.

In mid to late August, observers returned to locations previously surveyed within the study area where goshawks or unidentified raptor vocalizations had been reported either in 1993 or previous years but where nests had not been found. We conducted intensive calling surveys and visual searches for nests in mature timber stands within 2 km of reported observations. In addition, a few days were dedicated during the third week of August to search for fledged young in forested habitat located east of the designated survey area. We surveyed prime habitat (mature Douglas fir stands on north facing slopes selected prior to the surveys from aerial photos) along Trail Creek, Lake Creek, Coal Mine, and Aldous-Hancock Lake trails.

Four of the seven designated sampling subsections located at elevations below 2439 m were surveyed prior to the three high elevation sections due to the persistence of snow and wet trails until late June in 1993. We randomly selected the section and transects to be surveyed each day. Exceptions to this occurred for some transects located in the interior of the study area. For these, base camps were set up and surveys were clustered for 2-3 day periods in one area. During the same day, observers worked

transect lines set at least two lines apart to avoid mistaking broadcast calls for hawk responses.

Hawk responses to taped calls were classified by type and species. Possible goshawk responses included vocalization, approach and vocalization, silent approach, and fly-by with or without vocalization. Observers recorded the station, time, species, type of response, distance to hawk, age and sex of hawk if determined, and bearing of hawk if sighted in flight. We also noted responses from other bird species. After a goshawk response, 30-60 minutes were allocated to search for an active nest before continuing the survey. If no nest was located after a response, a team of two or three people would return and search within 2 km of the response location. Once an active nest was located, no additional surveys were conducted within 1.2 km of that nest. This prevented disturbance to nesting hawks and also increased survey efficiency since distances between goshawk nests on the TNF and in other areas of the western United States have been found to exceed 1.2 km (Reynolds 1983, Woodbridge and Detrich 1994, Patla, unpubl. data).

Two volunteer research interns completed all transect surveys. They received instructions on identification and vocalizations of local raptor species. Visits to active nest sites and observation periods in a blind placed 35 m from a goshawk nest familiarized them with specific goshawk behaviors and calls. They were also trained to recognize imitative calls by other species such as the Gray Jay (*Perisoreus canadensis*) and Steller's Jay (*Cyanocitta stelleri*). Before commencing transect surveys, they attended a two-day workshop (Idaho State University Outdoor Program) in map interpretation and orienteering.

SURVEY ANALYSIS

We mapped locations of all active and alternate goshawk nests on aerial photos (1:15,800) and 7.5 min USGS orthoquad maps. Precise UTM coordinates were

obtained using a Trimble Basic Geographic Positioning System (GPS) unit. Satellite fixes were collected in the 3-D mode. We then differentially corrected positions using a local base station. Distances to nearest water source from all nests were measured on quadrangle maps and also with the GPS software (PFINDER) mapping function. We measured inter-nest distances using GPS software as well.

RIPARIAN AREA/GIS LANDSCAPE ANALYSIS

Riparian areas found closest to active goshawk nests were classified according to two different systems: a riparian community type classification developed by the USFS for eastern Idaho and western Wyoming (Youngblood et al. 1985), and a riparian habitat gradient developed in the Centennial Mountains for a study of non-raptorial bird distribution (Douglas, et al. 1992). A TNF botanist, Stuart Markow, assisted in identification of riparian vegetation species.

TNF provided forest-wide ARC/INFO GIS coverages for vegetation, drainages, water sources, and roads for habitat analysis of the study area. The vegetation layer was developed from existing forest stand inventory data. Landsat images were used by the Forest to classify those areas not covered in the forest stand inventory database. A stand (polygon) was classified as being covered by a single tree species if inventory plots contained 85% or more of that species based on density estimates. Otherwise it was identified as a mixed species stand. Forested stands were also classified to size/age class and harvest history.

We created a separate GIS coverage of the study area to determine area surveyed, and also to measure the proportion of cover types existing within the area. Based on previously reported distances of goshawk nest sites to water in the Rocky Mountains (Shuster 1980, Patla unpubl. data), we classified the study area into either **near-riparian** (all area located within 250 m buffers set around permanent water sources) or

non-riparian (all remaining area outside of the 250 m buffer zones) (Fig. 3). We decided not to include intermittent water sources in our analysis since variable drought conditions during the past few years may have reduced the riparian value of this type of stream. We calculated the proportion of mature forest habitat within the entire study area and the near-riparian zones. To determine if goshawks used near-riparian zones preferentially over non-riparian habitat, we planned to use the log-likelihood ratio (Goodness of Fit Test) based on existing proportions of suitable nesting habitat (i.e. mature forest habitat) found within each area respectively.

HABITAT ANALYSIS METHODS

Vegetation analysis at nest sites followed the protocol used previously for measuring goshawk nests on the Forest (James and Shugart 1970, Patla 1991). Within a 20.1 m (66 ft) radius circle sample plot (0.127 ha/0.05 ac) centered at a nest tree, we counted all trees greater than 3.8 cm (1.5 in) and measured dbh (diameter at 1.4 m/4.5 ft height above the ground) using a standard dbh measuring tape. Understory vegetation height was measured along two 20 m transects placed randomly within the circular plot. We calculated nest tree canopy cover using a spherical densiometer (Forest Densiometers Model A), taking readings in the four cardinal directions below the nest tree. For nest site canopy cover, we averaged sixteen readings: four taken at each cardinal point on the perimeter of the sample plot. Tree height, nest height, and slope were measured with a Suunto clinometer.

Using aerial photos and orthoquad maps, we also determined distance from the most recently occupied nest tree within a territory to the nearest open road and forest edge. We measured distance to roads that were open (ungated), officially identified by a USFS number, and that appeared on recent Forest Service district travel maps. Edges were identified on aerial photos as the nearest boundary between the contiguous patch of mature forest containing a nest site and another major cover type or ecotone.

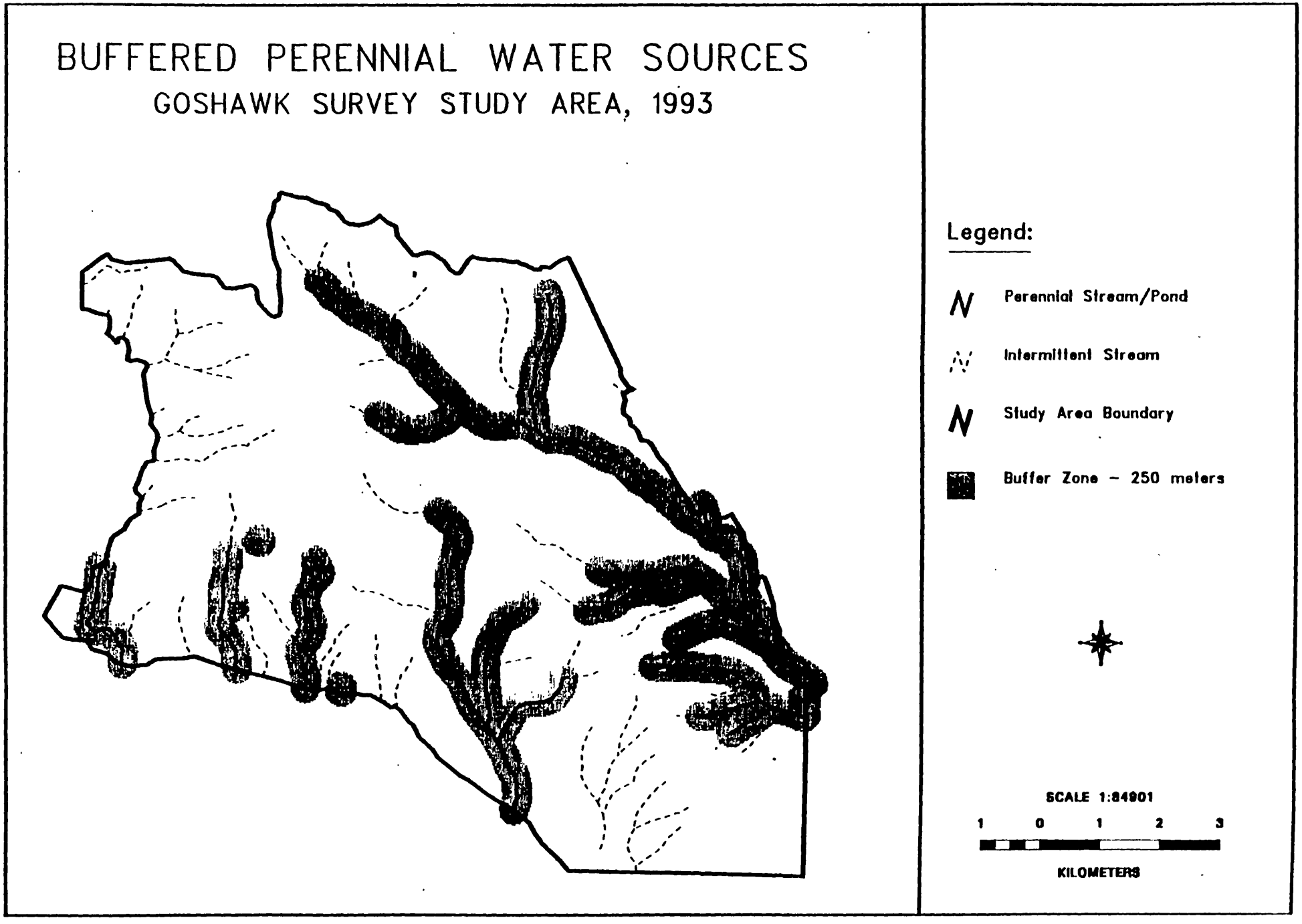

FIG. 3. GIS coverage of goshawk survey area showing perennial drainages with 250 m buffer zones used to calculate near-

TABLE 1. Mean monthly temperature (°C), precipitation (cm), and departure from 30 year mean in vicinity of goshawk survey study area. Data from Dubois Experimental Station (Station #[illegible]. Lat. 44[illegible]. Long. 11212 Elev. 1662 m).

MONTH	AVG TEMP (°C)	DEPARTURE FROM 30 YR MEAN	TOTAL PRECIPITATION (cm)	DEPARTURE FROM 30 YR MEAN
APR	4.5	1.4	4.78	2.13
MAY	12.2	-2.5	9.09	4.83
JUNE	13.1	-5.3	4.75	0.15
JULY	14.5	-2.8	5.23	2.41
AUG	16.6	-0.2	3.48	0.76
MEAN		-1.9		2.1
STD		-15.6		2.06

TABLE 2. Date and location of northern goshawk sightings within survey area (1993), Centennial Mts., Targhee National Forest, Idaho. Locations of active nest areas have not been included in the list below for protection of nesting territories. NOGO = Northern Goshawk.

DATE	SIGHTING	TRS	OBSERVATIONS
NEST AREA #1			
6/25	adult male		Male flew over
6/26	pair		Pair vocalizing by active nest along transect
7/01	NOGO nest		Nest check; female called 70 m from nest
7/13	nest check		Female called when oberservers 30 m from nest
			One downy young on nest; pin feathers pushing
7/21	nest check		Female dove at obs., one young with downy underside on nest
7/26	nest check		Young on edge of nest; almost completely feathered
7/27	NOGO feathers		NOGO feathers & grouse remains; head Spring Cr.
7/30	nest check		Young fledged; perched 50 m from nest at same height
8/06	fledge check		No goshawks seen or heard
8/11	fledge check		Played wail call; no goshawks seen/heard
8/13	fledge check		Checked nest area again; no goshawks present
NEST AREA #2			
6/26	adult female		Responded to tape: calls and approach
7/01	NOGO nest		Found nest 350 m from where female called 6/26
7/13	nest check		Female dove at observers 30 m from nest
			One young on ground; other branching
8/06	fledge check		Two fledges 300 m from nest; calling loudly
OTHER SIGHTINGS			
6/17	adult	T14N R38E S36	Castle Peak area: flew in, did not vocalize
7/29	adult male	T14N R38E S19	Carrying prey over Pete Creek Divide
8/12	adult	T14N R37E S19	Flew over same location Pete Creek Dvide

July 1 after a three hour search by three observers. We found the nest tree in an adjacent drainage 350 m from where the adult female first responded to the taped call. During this second nest search on July 1, we also discovered great gray owls (*Strix nebulosa*) which nested in an alternate goshawk stick nest. Two recently fledged great gray owls (GGOW) and an adult were found roosting within 75 m of the nest tree. Distance between the active goshawk nest and the active owl nest measured 476 m.

We searched for alternate nests within a 0.8 km (.5 mi) radius of the two active goshawk nest sites. Five alternate nests were found: four within 400 m of Nest #1 and one 476 m from Nest #2 (Table 3). All seven nest trees (active and alternate) were located within 250 m of a permanent water source which placed them within our defined near-riparian zone (Table 3).

Three other observations of adult goshawks did not result in location of active nesting territories. An adult male was seen on June 17 near Castle Peak on the western end of the study area. On two separate days (July 29 and August 12), a male was seen just south of the Continental Divide flying along a ridge east of Pete Creek (Table 2). The male sighted in July was carrying prey (medium sized bird). We obtained a bearing on this bird as it passed overhead but this did not lead us to suitable nesting habitat in the immediate vicinity. Further broadcast surveys and visual searches of mature stands in the Pete Creek/Castle Peak area did not result in additional goshawk sightings or evidence of nesting activity. From the bearing obtained in July, it is possible that the male goshawk sighted was returning to Nest #2 which was located 4.9 km (3.0 mi) to the southeast.

Other bird species which responded to the broadcast goshawk vocalizations during surveys included gray jay (the most frequent respondent), Steller's jay , northern flicker (*Colaptes aurates*), Clark's nutcracker (*Nucifraga columbiana*), red-breasted nuthatch

TABLE 3. Distance (m) between active and alternate goshawk nests within the same territories, and distance between all nest trees and nearest water source found within the survey study area (1993), Centennial Mts., Targhee N.F. Nests were clustered around one stream (A) in nest area #1. Two streams bisected nest area #2 (B and C). Distance between the two occupied nest sites found measured 7.5 km.

NEST AREA	NEST	DISTANCE TO ACTIVE NEST (m)	DISTANCE TO WATER SOURCE (m)	TYPE WATER SOURCE
#1	active		234	first order stream A
	alternate #2a	118	196	first order stream A
	alternate #2b	114	196	first order stream A
	alternate #3	219	15	first order stream A
	alternate #4	462	224	first order stream A
#2	active		81	first order stream B
	alternate #2	476	118	first order stream C
	MEAN		152	
	SD		82.4	

(*Sitta canadensis*), common raven (*Corvus corax*), and red-tailed hawk (*Buteo jamaicensis*).

Nine species of diurnal raptors, other than northern goshawk, and two species of owls were observed within the survey area (Tables 4-6). Red-tailed hawk was the raptor sighted most frequently (Table 4). It was seen throughout the survey period and study area with sightings concentrated near forest edges. On one occasion in July, near goshawk Nest #1, we observed an adult red-tailed hawk chasing a goshawk above the canopy.

Great horned owls (*Bubo virginianus*) were sighted on four separate occasions (Table 6). They were always seen near the edge of the forest or in very open stands. In addition to the active great gray owl nest found near the active goshawk Nest #1, an adult great gray owl was observed twice during the month of July roosting in mature Douglas fir trees in the vicinity of Nest #2. We searched for fledged owls and owl nests in this area but did not find any signs indicating the presence of an active nest site.

GOSHAWK PRODUCTIVITY

Three goshawks fledged from active nesting territories within the study area in 1993: two fledged on or near July 13 (Nest #2), and one fledged (Nest #1) almost two weeks later on July 28/29 (Table 2). The fledglings from the first site remained in the nest stand at least until August 8. The solitary fledgling at the other site was seen only one time post-fledging. During later visits to the nesting area, we did not see or hear the young or the adults at this site (Table 2).

TABLE 4. Location and date of Buteo hawks sighted within and adjacent to goshawk survey area, Centennial Mts., ID. Species code: RTHA Red-tailed Hawk; SWHA Swainson's Hawk; NOGO Northern Goshawk; GGOW Great Gray Owl

DATE	SPECIES	TRS	COMMENTS
6/17	RTHA	T13N R38E S6	
6/17	RTHA	T13N R39E S18	
6/18	RTHA	T13N R38E S4	
6/18	RTHA	T13N R38E S3	
6/22	RTHA	T13N R38E S2	
6/23	RTHA	T14N R38E S35	
6/23	RTHA	T13N R38E S14	
6/25	RTHA	T13N R38E S4	
6/25	RTHA (imm)	T13N R38E S12	
6/26	RTHA	T13N R38E S6	
7/10	RTHA	T14N R38E S33	
7/13	RTHA/NOGO	T13N R38E	RTHA chasing NOGO near nest site
7/13	RTHA	T13N R38E	Vocalized; near GGOW nest site
7/29	RTHA	T14N R37E S13	
7/31	RTHA	T14N R37E S28	
7/31	RTHA	T14N R37E S24	
8/05	RTHA	T14N R37E S25	
8/05	RTHA	T14N R37E S36	
8/12	RTHA-pair	T14N R37E S14	Soaring north of Pete Creek
8/13	RTHA	T14N R38E S26	Trail Creek east of study area
8/13	RTHA	T14N R38E S15	North of Burnt Canyon
8/14	RTHA	T14N R38E S24	

TABLE 5. Location and date of raptor species other than Buteos sighted within and adjacent to goshawk survey area, Centennial Mts., ID. Species code: AMKE American Kestrel; BAEA Bald Eagle; GOEA Golden Eagle; TUVU Turkey Vulture; COHA Cooper's Hawk; SSHA Sharp-shinned Hawk, OSP Osprey.

DATE	SPECIES	TRS	COMMENTS
FALCONS, EAGLES AND OSPRE			
8/13/93	AMKE	T14N R38E S26	Trail Creek east of study area
8/15/93	AMKE	T14N R39E S19	Coal Mine east of study area
8/13/93	BAEA-immat	T14N R38E S15	North of Burnt Canyon
7/14/93	GOEA	T14N R38E S31	Elevation 2560 m; soaring over ridge
7/28/93	GOEA	T14N R38E S32	
8/12/93	GOEA	T14N R37E S14	Soaring north of Pete Creek
6/17/93	TUVU	T13N R38E S1	
6/25/93	TUVU	T13N R38E S11	
6/30/93	TUVU	T13N R39E S19	
6/19/93	OSP	T13N R37E S11	
8/15/93	OSP	T14N R39E S19	Coal Mine east of study area
ACCIPITERS			
7/10/93	COHA	T14N R38E S28	Probable; heard one call
6/18/93	SSHA	T13N R38E S4	
6/18/93	SSHA	T13N R38E S12	Chased a RTHA
7/21/93	SSHA	T13N R38E S12	Defensive behavior; plucking post
7/28/93	SSHA	T14N R38E S32	
8/11/93	SSHA	T13N R38E	Adult perched in goshawk nest stand; no gos present
8/13/93	SSHA	T14N R38E S15	North of Burnt Canyon
8/14/93	SSHA	T14N R39E S19	Trail Creek east of study area
8/15/93	SSHA	T14N R39E S19	Coon Creek east of study area

TABLE 6. Location and date of owl species sighted within and adjacent to goshawk survey area, Centennial Mts., ID. Species code: GGOW Great Gray Owl; GHOW Great Horned Owl; NOGO Northern Goshawk.

DATE	SPECIES	TRS	COMMENTS
6/17	GHOW	T14N R38E S36	
6/30	GHOW	T13N R38E S15	
7/01	GGOW	T13N R38E S6	Adult/2 fledged young
7/02	GHOW	T14N R38E S35	
7/13	GGOW	T13N R38E	Seen 60 m from NOGO alt nest #2
7/30	GGOW	T13N R38E S12	Saw Creek area
8/05	GHOW	T14N R38E S34	
8/11	GGOW	T13N R38E S12	Seen again east of goshawk nest area

RIPARIAN ZONE NESTING AREAS

The two active nests and five associated alternate nests found all fell within our defined near-riparian zone, i.e. within 250 m of a permanent water source (Fig. 4). In nest area #1, all five nests occurred near the base of a steep forested ridge along a similar elevation gradient. One stream bisected this nesting area. In nest area #2, the two nest trees found were in separate, adjacent drainages and each was associated with a different stream. Mean distance from all nests to a permanent water source measured 152 m (82 m SD) (standard deviation) (Table 3). The three water sources located closest to goshawk nests were all first order streams (Cuplin 1986). These three streams originated at springs and were very narrow (less than 30 cm), low gradient, and quiet but had persistent flow even into the dry, fall months.

Two of the streams (A & B, Table 3, Fig. 4) were less than 0.8 km long; both disappeared underground before encountering another stream channel. One of these short streams (B) did not appear on topographic maps or on the TNF GIS stream coverage. Two streams (A & C) flowed through forest stands and conifers occurred close to stream edges. The third stream (B) flowed down the center of a long narrow meadow 100 m wide by 450 m long. Nest #2 was set back 60 m from the edge of this meadow but could not be seen from it.

Riparian habitats found near nest sites corresponded closest to the "mesic forb meadow" community type described by Youngblood, et al. (1985). As defined by Douglas (1992), two stream riparian habitats (A & C) corresponded to region I "conifer dominated" communities and one (B) to region II mesic meadow communities/conifer edge although Douglas fir rather than lodgepole pine (*Pinus contorta*) bordered the meadow in our study area. Bird species found associated with conifer-dominated riparian areas in the Centennial Mountains included yellow-rumped warbler (*Dendroica coronata*), dark-eyed junco (*Junco hyemolis*), mountain chickadee (*Parus gambeli*), and western tanager (*Piranga ludoviciana*) (Douglas et al. 1992).

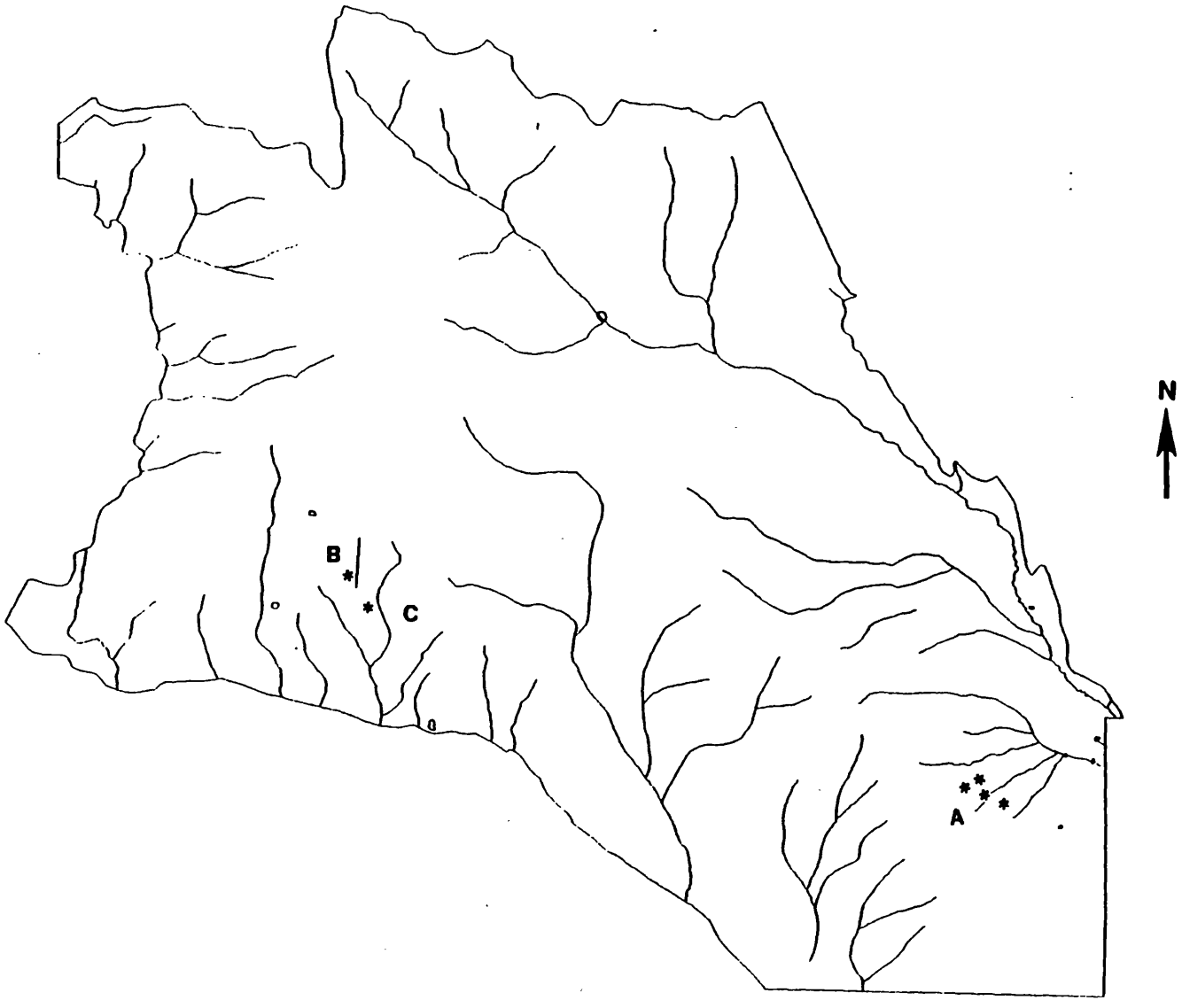

FIG. 4. ARC/INFO GIS map of survey study area showing goshawk nest site locations (stars) and water sources including streams, springs and ponds. Letters indicate streams located closest to active and alternate goshawk nests. See text for description of these streams and associated riparian habitats.

Riparian habitats located closest to goshawk nests were characterized by a variety of forbs and grasses (Table 7). Most of the species listed in Table 7 are those associated with damp to wet soils (Craighead et al. 1963, Hitchcock and Cronquist 1973, Markow and Fertig 1993). Along the stream near Nest #1, we found the first reported specimens of lady fern (*Athyrium filix-femina*) for the Centennial Mountains (Stuart Markow, TNF field botanist).

GIS LANDSCAPE ANALYSIS AND NEST SITE DENSITY

Using ARC/INFO GIS software, we calculated that 21.52 km^2 or 25.4% of the study area (84.70 km^2 total) fell within 250 m of a permanent water source which we defined as the near-riparian zone (Fig 4). Distribution of vegetation cover types within the near-riparian zone was similar to that found within the study area over all (Table 8). Mature timber covered over 70% of the entire area; 75.8% of the near-riparian was also classified as mature timber habitat. Douglas fir stands accounted for 68% of existing mature forest habitat (Table 9). Considering overall mature forest habitat, 27.0% (16.3/60.4 km^2) was located within the near-riparian zone (Table 8). The percentage of total mature Douglas fir habitat contained within the near-riparian zone was similar, 27.2% (11.2/41.2 km^2) (Table 9).

Density of goshawk nesting pairs or territories for the entire study area (84.7 km^2) was 1 pair/42.4 km^2 (16.4 mi^2) or 0.24 territory/1000 ha. Considering only suitable habitat (mature forest/GIS size class 9) within the study area, goshawk nesting density was 1 pair per 30.2 km^2 (11.7 mi^2) or 0.33 territory/1000 ha. Since nests were found only in Douglas fir stands, density calculated for that cover type alone equals 1 pair per 20.6 km^2 (8.0 mi^2) or 0.48 territory/1000 ha.

Given the low number of nesting areas found (n=2), we could not perform any rigorous statistical testing of goshawk habitat selection for near-riparian areas.

TABLE 7. Plant species found in riparian areas at permanent water sources closest to goshawk nest sites, survey study area (1993), Centennial Mts., Targhee National Forest, eastern Idaho. Plants identified by Stuart Markow, Botanist, Targhee National Forest.

FAMILY	SPECIES NAME	NEST #1	NEST #2	NEST #2ALT
Apiaceae	Angelica arguta	x		x
Apiaceae	Heracleum sphondylium		x	x
Asteraceae	Achillea millefolium		x	
Asteraceae	Aster conspicuus	x		
Asteraceae	Aster foliaceus			x
Asteraceae	Aster, sp.			
Asteraceae	Rudbeckia occidentalis	x	x	x
Asteraceae	Senecio serra		x	
Asteraceae	Senecio triangularis	x		x
Brassicaeae	Arabis, sp.		x	
Caprifoliaceae	Lonicera utahensis	x		
Cornaceae	Cornus sericea	x		
Cyperaceae	Carex aquatilis		x	
Cyperaceae	Carex microptera		x	x
Cyperaceae	Carex rostrata	x	x	x
Geraniaceae	Geranium viscosissimum	x	x	x
Grossulariaceae	Ribes hudsonianum	x		
Grossulariaceae	Ribes lacustre			x
Juncaceae	Juncus ensifolius		x	
Lamiaceae	Mentha arvensis		x	
Onagraceae	Epilobium ciliatum	x	x	x
Orchidaceae	Habenaria, sp.			x
Poaceae	Calamagrostis inexpansa	x	x	
Poaceae	Elymus glaucus		x	x
Poaceae	Glyceria elata	x	x	x
Poaceae	Phleum pratense		x	
Poaceae	Poa palustris		x	
Polemoniaceae	Polemonium occidentale		x	
Polypodiaceae	Athyrium filix-femina*	x		
Primulaceae	Thalictrum, sp.	x		
Ranunculaceae	Aconitum columbianum		x	
Ranunculaceae	Actea rubra	x		
Rosaceae	Fragaria vesca	x		
Rosaceae	Geum, sp.	x		x
Rosaceae	Rubus parviflorus	x		
Rosaeae	Potentilla gracilis		x	
Rubiaceae	Galium trifidum		x	
Saxifragaceae	Saxifraga odontoloma	x		x
Scrophulariaceae	Mimulus guttatus		x	x
Scrophulariaceae	Mimulus lewisii	x		

*First record for the Centennial Mountains, Targhee National Forest, Idaho

TABLE 8. Landscape analysis of survey study area and near-riparian buffer areas showing cover type, code, area, and percent of total area. Area data calculated from ARC/INFO GIS coverages provided by Targhee National For

		STUDY AREA		NEAR RIPARIAN AREAS	
COVER TYPE*	VEG CODE	AREA (km^2)	PERCENT	AREA (km^2)	PERCENT
Mature Timber	9	60.40	71.3	16.30	75.8
Mature Harvested	1DF	6.76	8.0	1.49	6.9
Pole Timber	8	1.09	1.3	0.29	1.3
Seedling Timber	6	2.70	3.2	0.87	4.0
Nonstocked	5	1.89	2.2	0.13	0.6
Tall sage/grass	TSG	7.00	8.3	1.30	6.0
Grass/forb	GRF	2.51	3.0	0.35	1.6
Grass/brush	GRB	0.59	0.7	0.15	0.7
Grass	GR	0.69	0.8	0.37	1.7
Mountain Brush	MB	0.06	0.1	0.06	0.3
Rock	R	0.31	0.4	0.06	0.3
Miscellaneous		0.70	0.8	0.15	0.7
TOTAL		84.70	100.0	21.52	100.0

*Vegetation Timber Classifications:

Mature	Douglas fir (DF) >20.3 cm dbh, other conifers >17.8 cm dbh
Pole	DF 7.8-20.3 cm dbh, other conifers 7.8-17.8 cm dbh
Seedling	15.2 cm height to 2.5 cm dbh
Nonstocked	seedlings less than 15.2 cm height

TABLE 9. Summary of mature forest area classified by tree species found within goshawk survey area and near riparian zones calculated from ARC/INFO GIS coverages. Vegetation coverage from Targhee NF timber stand inventory and Landsat analysis provided by the Forest. The near riparian buffer zones contained 27% of mature forest habitat found within the study area.

TREE SPECIES	VEG CODE	MATURE TIMBER STUDY AREA (KM^2)	MATURE TIMBER STUDY AREA (percent)	MATURE TIMBER NEAR RIPARAIN (KM^2)	MATURE TIMBER NEAR RIPARAIN (percent)
Douglas fir	DF9	41.20	68.2	11.2	68.7
Douglas fir unclassified	NDF9	6.17	10.2	1.2	7.4
Mixed conifer	MX39	8.09	13.4	3.0	18.4
Lodgepole pine	LP9	1.22	2.0	0.4	2.5
Subalpine fir	SF9	1.95	3.2	0.2	1.2
Whitebark pine	WB9	0.81	1.3	0.0	0.0
Limber Pine	LM9	0.46	0.8	0.0	0.0
Aspen	AS9	0.48	0.8	0.3	1.8
TOTAL		60.38	100	16.30	100.00

However, the fact that all seven nest trees were found within the near-riparian zone even though it comprised only 27% of suitable habitat surveyed suggests that it is an important factor in goshawk nest site selection in undisturbed Douglas fir forests in the Centennial Mountains.

NEST SITE HABITAT DATA

All seven goshawk nests found within the study area were in large, mature Douglas fir trees which were codominant (forming part of the main upper canopy layer) or dominant (extending above the main upper canopy layer). Nest tree, nest stand and topographic variables measured for the seven active and alternate goshawk nests all fell within the range reported for 37 other occupied Douglas fir nest sites found on the Forest (Table 10 and 11). Mean values for tree height, nest height, tree dbh and elevation, however, exceeded the 95% confidence level determined for the 37 other nests (Table 10).

Study area nest trees were found between 2116 m and 2250 m (6940-7380 ft) elevation (Table 10). Mean dbh of nest trees was 59.1 cm/23.2 in (4.7 cm/1.8 in SD); tree height averaged 29.7 m/97.4 ft (3.4 m/11.2 ft SD), and mean tree age was 153 years (26.8 SD). Goshawks placed nests below the green canopy at an average height of 15.6 m/51.2 ft (1.8 m/5.9 ft SD). Nest height to tree height ratio was 0.52.

Nest trees in the study area were placed on 10-47% slopes (average 25%) with north to northeast aspects (0 to 50 degrees) (Table 11). Canopy cover averaged 82% both under the nest tree and at the edge of the 20.1 m radius habitat plot.

We measured nest site vegetation plots at six of the seven nest trees located within the study area. We did not take plot data at one alternate nest tree in nest area #1 as it was located only 16 m from another alternate; we measured the tree which appeared to contain the most recent stick nest. Douglas fir was the only mature conifer (defined as

TABLE 10. Comparison of nest tree habitat data from study area goshawk nest sites (active and alternate) found in the Centennial Mts. (1993) to occupied Douglas fir goshawk nests found throughout the Targhee National Forest between 1989 and 1993. DF= Douglas fir. SE=standard error. CL=confidence limits.

Variable		ALL DF NESTS (n=37)	ACTIVE NESTS SURVEY AREA (n=2)	ALTERNATE NESTS SURVEY AREA (n=5)
TREE HEIGHT (m)	mean	26	31	29
	range	12-38	30-32	26-36
	SE	0.9		
	95% CL	24.4-27.9		
NEST HEIGHT (m)	mean	13	15	16
	range	7-21	12-18	15-16
	SE	0.5		
	95% CL	11.7-13.7		
TREE AGE (year)	mean	145	131	169
	range	62-280	127-134	127-191
	SE	11.9		
	95% CL	120-169		
TREE DBH (cm)	mean	48	61	58
	range	21-84	59-64	50-64
	SE	2.7		
	95% CL	42.3-53.2		
TREE CANOPY COVER (%)	mean	86	85	81
	range	64-96	80-90	66-92
	SE	1.3	5	
	95% CL	84-89		
ELEVATION (m)	mean	2136	2197	2146
	range	1860-2296	2143-2250	2116-2210
	SE	14.4		
	95% CL	2107-2165		

TABLE 11. Comparison of nest site habitat data from study area goshawk nests (active and alternate) found in the Centennial Mountains (1993) to occupied Douglas fir goshawk nests sites found throughout the Targhee National Forest (1989-1993). Plot size used to collect site data was a 20.1 m radius circle centered on nest tree (.127 ha). Sawtimber=trees > 17.8 cm dbh. DF=Douglas fir. SE=standard error. CL=confidence limits.

Variable		ALL DF NEST SITES (n=30)	ACTIVE NEST SITES SURVEY AREA (n=2)	ALTERNATE NEST SITES SURVEY AREA (n=5)
SAWTIMBER				
AVG DBH (cm)	mean	33	37	36
	range	24-47	36-39	31-41
	SE	1.1		
	95% CL	31.3-35.6		
# TREES/HA	mean	382	350	464
	range	134-717	236-465	378-598
	SE	26.6		
	95% CL	327-436		
SNAGS				
AVG DBH (cm)	mean	15	15	20
	range	9-38	11-18	14-24
	SE	1.3		
	95% CL	12.8-18.0		
# SNAGS/HA	mean	241	323	281
	range	24-614	32-614	126-661
	SE	31.1		
	95% CL	178-305		
GROUNDCOVER HEIGHT (cm)	mean	19.5	16.6	18.0
	range	1.4-50.1	7.8-25.4	11.0-25.8
	SE	1.8		
	95% CL	15.8-23.3		
CANOPY COVER (%)	mean	79	86	80
	range	60-93	77-94	67-88
	SE	1.7		
	95% CL	76-82		
SLOPE (%)	mean	24	33	21
	range	0-43	18-47	10-37
	SE	1.9		
	95% CL	20-28		

trees > 17.8 cm/7 in dbh) in four of the six plots. Two of the plots had small percentages of mature subalpine fir and lodgepole pine (8% and 16%).

We found an average of 426 live mature trees/ha (170 trees/acre) at goshawk nest sites (range 236-598 trees/ha; 122 SD). Mean dbh of mature conifers was 36.6 cm/14.4 in (3.5 cm/1.4 in SD). Snags (dbh greater than 1.5 cm) averaged 18.2 cm/7.2 in (4.7 cm/1.3 in SD). We measured an average of 295 snags/ha (119 snags/acre) (range 32-661 snags/ha; 271.1 SD). Understory vegetation at study area nest sites consisted mainly of short grasses and forbs. Average height of ground vegetation measured 17.5 cm/6.9 in (8.1 cm/3.2 in SD).

Summarizing nest tree and nest site habitat parameters, goshawk nests in the study area were found in stands of large, well developed, mature Douglas firs with dense canopy cover. Trees in the study area nest sites averaged slightly larger in size compared to other Douglas fir nest sites on the Forest (Table 10 and 11). Large areas of contiguous mature forest habitat surrounded nest sites. Percent of mature forest (GIS size class 9) surrounding nest areas #1 and #2 within 284 ha (700 ac) measured 93% and 98% respectively (ARC/INFO GIS analysis). Within 910 ha (2250 ac) of these nests areas, percentage of mature forest was 94% and 86% respectively.

At two nest sites in the Saw Creek area, we found two and four cut stumps respectively of mature trees within the sample plots. Stumps ranged in diameter from 0.6 to 0.85 m (2-2.8 ft). Canopy cover at these sites averaged 70%, which was lower than the 80-90% measured in unharvested sites. Based on these two plots, we estimated that selective harvesting in this area during the late 1970's removed between 16-32 trees/ha (6-13 trees/acre).

Nesting territories found in the study area were located on average closer to water sources and farther from edges and roads compared to other goshawk nest territories (Table 12). Mean distance to water source was 158 m (108 SD) for study

TABLE 12. Distance (m) from last known occupied nest to forest edge, open road, and permanent water source comparing territories found in survey study area (n=2) to other occupied Douglas fir nesting territories (n=25) found on the Targhee National Forest. See Table 13 for statistical evaluation of results.

	DOUGLAS FIR NESTS (n=25)	SURVEY AREA NESTS (n=2)
DISTANCE TO EDGE (m)		
mean	272	934
SD	300	244
minimum	12	762
maximum	915	1107
DISTANCE TO MAIN ROAD (m)		
mean	1311	1677
SD	948	378
minimum	84	1410
maximum	4878	1944
DISTANCE TO WATER (m)		
mean	558	158
SD	626	108
minimum	15	81
maximum	2706	234

nests (n=2) and 558 m (626 SD) for other nest territories (n=25). Study area occupied nests occurred at a mean distance of 934 m (244 SD) from the edge of forest habitat compared to 272 m (300 SD) for other nesting territories. Mean distance to road measured 1677 m (378 SD) for study nests compared to 1311 m (948 SD) for other areas.

STATISTICAL ANALYSIS OF HABITAT DATA

To determine if habitat variables differed significantly between the occupied nests (n=2) found in 1993 and other occupied Douglas fir nest sites (n=37) found opportunistically on the TNF between 1989 and 1993, and to test the recently developed multiresponse permutation procedures (MRPP), we ran six different statistical analyses and compared probability values (Table 13). For analysis of all variables except distance data, each occupied nest site was considered an independent sample unit as nest trees varied considerably in size even within the same territory. Also average distance between nest trees was greater than 250 m (Patla, unpubl. data) and nest site plots within the same territories did not overlap (Buchanan 1991). Sixteen variables were analyzed using a non-parametric test (Mann-Whitney U), a T-test with all data subjected to square-root transformations, T-tests using non-transformed data calculated with pooled variances (the standard method) and separate variances which Systat recommends for samples having different sizes and standard deviations (Berk 1994), and two multi-response permutation procedures (MRPP). One MRPP emulated the standard T test using squared Euclidean distances (v=2, c=2) and the other used unsquared distances (v=1) for distribution-free analysis (Slauson et al. 1991) (Table 13). Density plots showed that some of the variables tested showed skewed or non-normal distributions. Results from using square root transformations corrected for skewness in some variables much more than others.

Significant probability values (alpha < 0.05) using the separate variances T test (Systat) were computed for two variables: nest tree height (p=0.034) and nest tree dbh

TABLE 13. Comparison of probability values (p) using six different statistical methods to evaluate differences in habitat variables between study area nests (n=2) and other Douglas fir nest sites (n=37; except distance measurements n=25). Statistical tests used included Mann-Whitney U, T-test with square root transformation, T-test (calculated with both separate variances and pooled variances), and multi-response permutation procedure (MRPP) calculated with squared Euclidean distances (v=2) and unsquared distances (v=1). Also shown are the mean differences in probability between all tests and MRPP using Euclidean distances (v=1). See text for descriptions of MRPP. The only tests resulting in significant differences (alpha < 0.05) were separate variances T-tests for nest tree height and nest tree dbh, and all test results for distance from edge. (Note: exact MRPP p values could be calculated for the three distance measurements.)

HABITAT VARIABLE	MANN-WHIT U	T TEST SQR TRANS POOLED VAR	T TEST NO TRANS SEP VAR	T TEST NO TRANS POOLED VAR	MRPP V=2 C=2	MRPP v=1 C=1
Nest tree height	0.098	0.249	0.034	0.252	0.259	0.125
Nest height	0.372	0.319	0.562	0.310	0.316	0.760
Nest tree age	0.936	0.923	0.535	0.866	0.808	0.252
Nest tree dbh	0.203	0.237	0.019	0.253	0.277	0.143
Tree canopy cover %	0.640	0.850	0.864	0.833	0.648	0.783
Elevation	0.313	0.370	0.807	0.368	0.373	0.552
Sawtimber/ha	0.739	0.767	0.834	0.750	0.792	0.826
Sawtimber mean dbh	0.318	0.362	0.197	0.380	0.419	0.291
Snag/ha	0.907	0.869	0.950	0.547	0.595	0.949
Snag mean dbh	0.640	0.999	0.654	0.937	1.000	0.730
Ground cover height	1.000	0.823	0.883	0.791	0.748	0.934
Canopy cover nest site	0.317	0.222	0.580	0.317	0.336	0.750
Slope %	0.426	0.424	0.443	0.477	0.120	0.647
Distance to road	0.161	0.462	0.369	0.523	0.493	0.299
Distance to edge	0.037	0.018	0.013	0.006	0.011	0.028
Distance to water	0.228	0.319	0.020	0.383	0.328	0.316
MEAN (test p - MRPP p (for MRPP V=1, C=1)	-0.077	-0.017	-0.039	-0.039	-0.050	

(p=0.019) (Table 13). The only variable which differed significantly in more than one statistical test was distance to edge. Significant p values for this variable were obtained using all six statistical methods. Overall, probabilities obtained using the MRPP test based on Euclidean distances averaged slightly higher than the other statistical methods tested (Table 13). The test that resulted in probabilities most similar to those computed using MRPP (v=1) for this data set was the pooled variance T-test using square-root transformed variables (Table 13). Probabilities computed using the Mann-Whitney non-parametric test showed the greatest mean difference compared to MRPP (v=1) for this particular data set (Table 13). We found that probabilities obtained using the MRPP option (v=2, c=2) which mimics the classical parametric T-test compared very closely to the Systat pooled variances T-test: average difference in p value for 16 variables tested was 0.01.

We also used the MRPP ARC analysis for circular statistics to compare aspect of study sites with other Douglas fir nest sites. A significant difference in aspect was not found (p=0.658).

Overall, results of this statistical analysis support the null hypothesis that Douglas fir nest sites found using a systematic survey do not differ significantly from occupied Douglas fir sites found opportunistically on the TNF over the past decade except for distance to edge. Although sample numbers are small, these results suggest that it would be valid to use our accumulated database both to develop management strategies to conserve goshawk nesting habitat and to develop a predictive model to locate other Douglas fir nest sites on the Forest (Mosher et al. 1984). Testing of such a model would help to further refine our understanding of nest site selection by goshawks on the TNF.

DISCUSSION

WEATHER EFFECTS ON PRODUCTIVITY AND NEST SITE DENSITY

All of our study objectives (determining if goshawks preferentially select nesting areas close to water sources, describing water sources and riparian areas important for goshawk nest sites, measuring goshawk nest site density, and evaluating bias in our historical database) were hindered by the low number of occupied nests found within the study area. Considering the wet, cold spring and summer weather in 1993, it is possible that additional goshawk nesting territories may exist within the study area but were unoccupied in 1993.

In 1993, occupancy and productivity of previously identified goshawk nest sites on the Targhee National Forest were reduced compared to 1992 monitoring results. In 1992, we found 21 active nests which produced an average of 2.05 young per nest (1.07 SD). In 1993, surveying the same areas we found only 12 active nests (including nests found in this study) which produced an average of 1.42 young per nest (0.79 SD) (Patla, unpublished data). In 1992, 14% of nests produced 1 young and 29% of nests produced 3 or 4 young. In 1993, 50% of nests produced 1 young and 8% of nests produced 3 or 4 young. Substantial reduction in number of occupied territories and productivity were reported from areas in Oregon in 1993 as well (DeStefano et al. 1994).

Low productivity could indicate poor food supply prior to egg-laying or during the nesting period (Newton 1979). Increased attacks by older chicks on their smaller siblings have been reported during periods of food shortages by *Accipiter* and *Buteo* species (Newton 1979). One study related brood reduction in red-tailed hawks to weather-dependent prey delivery (Stinson 1982). We also observed sibling aggression during blind observations at a goshawk nest in the Big Hole Mountains in 1993 but

recorded no acts of aggression during blind observations made at three different nests in 1992 (Patla unpublished data).

To investigate the relationship between productivity (the number of fledglings produced per nest per year) and weather, we ran single and step-wise regressions examining weather factors during the nest initiation, incubation, and nesting periods (March through May) from 1989-1993. We did not test weather effects for the late nesting and fledging period (June-August), as annual variation in temperature and precipitation for these months was very low compared to earlier months of the year. Specifically, we examined mean temperature and precipitation for the months of March, April, and May; snow depth in March; combined mean temperature, precipitation and snowfall for March and April, and combined mean temperature and precipitation for April and May (Table 14).

Significant individual correlations were found for April temperature ($r=0.984$, $p=0.002$), combined April/May temperature ($r=0.914$, $p=0.030$), and May precipitation ($r=0.921$, $p=0.026$) Correlations were positive for temperature and negative for precipitation. Using step-wise regression, only April temperature was selected as a significant predictor of goshawk productivity ($r^2=0.969$, $p=0.002$) (Systat, multiple regression). As estimated mean date of egg laying on the TNF is May 14 (range April 24- May 23), weather effects during the pre-incubation and early nesting period appear to influence goshawk productivity more than later in the nesting period.

Considering the five year period from 1989-1993 (Table 14), the lowest mean April temperatures occurred in 1993 and 1991. Mean productivity (#young produced per nest) in both years was below 2 young/successful nest. These results were similar to those reported from Germany where goshawk productivity was found to be positively correlated with temperature in April/May and May, and negatively correlated with rainfall days in May (Kostrzewa and Kostrzewa 1990).

TABLE 14. Weather data variables used to analyze the relationship between weather and goshawk productivity, 1989-1993. Mean temperature and precipitation data from Driggs, ID (St. #2676, Teton County, elevat. 1866 m). Snow data from Pine Creek Pass (St. #6720, Teton County, elevat. 2049 m). Mean monthy temperature and precipitation were tested for each month alone and for grouped months, March/April and April/May. See text for analysis results.

YEAR	#YOUNG GOSHAWKS PER NEST	MAR+AP SNOWFALL (cm)	MARCH SNOW DEP (cm)	MARCH TEMP (C)	APRIL TEMP (C)	MAY TEMP (C)	MARCH PRECIP (cm)	APRIL PRECIP (cm)	MAY PRECIP (cm)	MAR+AP TEMP (C)	MAR+AP PRECIP (cm)	AP+MAY TEMP (C)	AP+MAY PRECIP (cm)
1989	2.00	52.3	145	1	6	9.4	6.5	1.1	4.5	24	7.6	15.4	5.6
1990	2.25	38.7	61	1	7	8.3	0.9	4.9	3.8	25	5.9	15.3	8.7
1991	1.64	51.0	104	0	3	7.8	3.3	4.0	9.5	21	7.3	10.8	13.5
1992	2.26	25.2	58	3	7	11.7	2.5	1.9	2.3	28	4.4	18.7	4.2
1993	1.54	52.9	102	-2	2	9.4	2.2	6.2	7.5	17	6.4	11.4	13.7
30 YEAR Mean (1961-1990):				-2	4	9	2.8	3.3	5.1				

Nesting territories that were successful in a poor productivity year such as 1993 may indicate high quality sites which have a stable supply of food even in poor years (Newton 1979, 1986). If other nesting territories exist within the study area, they may be located in more marginal habitat than the nest territories that we found occupied in 1993. It is difficult to separate out the effects of territory quality from variation in individual pair productivity, however (Newton 1979).

DENSITY OF NESTING TERRITORIES

Traditional goshawk nesting territories contain a number of alternate nests and can be reoccupied by goshawks for many years (Woodbridge and Detrich 1994). Territories are often spaced regularly across the landscape where suitable habitat exists but at relatively low densities. Spacing of goshawk nests has been reported as mean nearest neighbor distance (Reynolds 1983). Mean internest distance for nests found in eastern Oregon was 5.6 km (range 2.4-8.4 km) (Reynolds 1983). Mean distance between 97 nests on the Wallowa-Whitman National Forest in eastern Oregon was reported to be 5.9 km (range not reported) (Anderson and Schommer 1992). On the Kaibab Plateau in northern Arizona, mean distance between 59 nearest neighboring nests was 3 km (range 1.6-6.4 km) with 47% of the nests occurring within 2.0-3.5 km of each other (Reynolds et al. 1994).

Density of nesting goshawks has been reported also as number of nesting pairs per 1000 ha. Reported densities from older studies made before broadcast vocalization survey methods became established ranged from 0.2 pairs/1000 ha in Alaska (McGowan 1975), 0.04-0.3 pairs/1000 ha in South Dakota (Bartelt 1977), 0.7 pairs/1000 ha in Colorado (Shuster 1977) to 1.1 pairs/ 1000 ha in Arizona (Crocker-Bedford and Chaney 1988). Nest density reported from recent surveys in Orgeon (1992-1993) was 0.6-0.7 active territories per 1000 ha (DeStefano et al. 1994).

Distance between occupied goshawk nests found in this study (7.5 km) fell within ranges but exceeded means reported from Oregon. Density of goshawk nesting pairs (0.33 active territories per 1000 ha of suitable habitat) was almost half of densities reported for Oregon but close to densities reported from Alaska and South Dakota. Results suggest that nesting density is low in the Centennial Mountains especially in a poor productivity year. Considering density data from eastern Oregon, other observations of goshawks from the study area (Table 2), and also that optimal detectability of the survey method used is probably close to 70% (Kennedy and Stahlecker 1993), we believe that at least one other nest site might be located within the study area especially during higher productivity years. However, fluctuating prey abundance and availability in the relatively harsh climate of the northern Rocky Mountain area may result in lower densities and more annual fluctuation in numbers of nesting goshawk pairs compared to the southwestern and coastal regions of the western United States.

IMPORTANCE OF RIPARIAN AREAS FOR GOSHAWK NESTING HABITAT

Although sample numbers were low, survey results suggest the importance of riparian habitats in goshawk nest site selection for birds nesting in large blocks of contiguous forest habitat. Nest trees, active and alternate, within the study area were located a mean distance of 152 m from first order streams (range 15-234 m) and all seven fell within our defined near-riparian zone of 250 m surrounding permanent water sources.

To further investigate the relationship between goshawk nest site locations and water sources, we compared distance to water from random habitat plots for nests found in the Centennial Mountains and those found elsewhere on the Forest (Table 15). Random sites selected within 13 Douglas fir nesting territories in the Centennial Mountains, including the two study area territories, were located a greater mean

TABLE 15. Distance (m) to water from goshawk nest sites and random sites on the Targhee National Forest comparing sites found in the Centennial Mountains to sites found at other locations on the Forest. Nest sites in both groups were located closer to water than random sites but differences were not statistically significant (PTMP permutation test for matched pairs).

GOSHAWK NEST SITE LOCATION	NEST SITES DISTANCE TO WATER (m)	RANDOM SITES DISTANCE TO WATER (m)	PTMP TEST P
Centennial Mountains			
mean	327	431	0.445
SE	126	163	
median	190	190	
n=13			
Outside of Centennial Mountains			
mean	666	805	0.463
SE	191	275	
median	419	534	
n=13			
All nest sites combined			
mean	528	605	0.462
SE	118	163	
median	267	419	
n=13			

distance from water sources than nests sites (431 m compared to 327 m) but this was not statistically significant (PTMP permutation test for matched pairs, p=0.445) (Slauson et al. 1994). The median distance to water was the same for both random and nest sites, 190 m, indicating that water sources were available throughout estimated home range areas.

Comparing distance to water from nest sites and random sites in nesting areas outside of the Centennial Mountains (n=14) for both lodgepole pine and Douglas fir nest sites, again distance from random sites was larger but not significant. Mean distance to water from nests was 666 m compared to 805 m from random sites (PTMP, p=0.0.463) (Table 15). Median distances were 419 m and 534 m respectively.

Considering overall mean distance to water, nests in the Centennial Mountains were located closer to water (327 m) than nests found elsewhere on the Forest (666 m) but this trend was not statistically significant (MRPP, v=1, p=0.114).

Overall, mean distance to water from occupied nesting territories measured throughout the forest (n=27) was 528 m (118 SE) compared to 605 m (163 SE) for random sites. Median distance from nests to water was 267 m. Thirty-nine percent (11/28) of these nests were located within 250 m of water, 57% (16/28) within 500 m and 75% (21/28) within 750 m. For the Centennial Mountain nest sites (n=13), 38% (5/13) occur within 250 m, and 62% within 500 m.

A few factors need to be considered when interpreting these results. First, it is not always possible in complex mountainous forest areas to find all water sources that might be available to resident goshawks. As indicated by one of the study sites, existing permanent water sources may not be identified on maps and related databases. Also intermittent and ephemeral water sources may be used by hawks especially early in the nesting season which were not included in our analysis.

The scale of analysis should also to be considered. It is likely that if random samples had been taken across the entire landscape, rather than just within a 2.4 km (1.5 mi) distance of active nests, the difference in distance to water between random and nest locations would have been more pronounced. If habitat selection by birds takes place in a hierarchical manner as proposed by Hutto (1985), the presence of water may be important in selection of a particular habitat rather than during the microhabitat site selection stage which is what our analysis focused on.

For our final analysis, to understand what water sources were most important for goshawk nesting habitat on the Forest, we classified the type of water source nearest to nest areas found outside of the study area (n=25): 12 (48%) were near first order streams, 6 (24%) by second or third order, 5 (20%) by springs, and 2 (8%) by ponds (Table 16). The distribution for random sites was very similar, indicating that this represents the proportion of water types available within estimated home range areas (Table 16).

Shuster (1976) suggested that in Colorado goshawks seem to avoid placing nests near large, noisy streams. Our data from the Targhee support this hypothesis as well as no nests have been found near fast moving, noisy streams or rivers. Observing female goshawks at the nest from blinds during the nesting period (1992-1993), it was obvious that the ability to hear played an important role both in nest defense and interactions with the adult male. The female would become very alert upon hearing noises whether from prey, potential predators, or calls from her mate. She would often leave the nest to investigate such sounds (Patla pers. obs). Noisy moving water would greatly hinder her ability to detect activity of predators or prey around the nest site.

Summarizing available data from goshawk habitat studies in the western United States, a majority of the nests measured fell within the 250 m buffer zone defined in this study as the near-riparian area (Table 17). Overall mean distance was 183 m (101 SE). Data from nest sites located at a great distance from water were not included in

TABLE 16. Types of permanent water sources found closest to goshawk nest sites and to random sites on the Targhee National Forest. Random sites were selected from within estimated home ranges (2.7 km radius of known nest sites). First order streams were the most common water source found within known nesting areas.

TYPES OF WATER SOURCES	NEST SITES	RANDOM SITES
FIRST ORDER STREAMS	12	15
SECOND/THIRD ORDER STREAMS	6	6
SPRINGS	5	2
PONDS	2	2
TOTAL SITES	25	25

TABLE 17. Distance (m) from northern goshawk nests to water sources in the western United States. Values indicated by asterisks (*) were reported as maximum distances only. NF stands for National Forest. Overall mean and standard error were calculated for areas which reported exact distances only.

LOCATION	DISTANCE (m) mean (SE)	#NESTS	REFERENCE
Montana Beaverhead NF	232 (35)	26	J. Kirkley (pers comm) Western Montana College
eastern Oregon			DeStefano & Meslow (1992)
Fremont NF	146 (43)	6	
Malheur NF	251 (65)	6	
Wallowa-Whitman NF	129 (67)	7	
northeastern Oregon	70 (23)	12	Bull and Hohman (1992)
northern Idaho, western Montan	<500*	17	Hayward and Escano (1991)
northern California	153 (65)	13	Hall (1984)
northeastern Oregon	199 (41)	34	Moore & Henny (1983)
eastern Oregon	119 (24)	50	Reynolds (1983)
northern Colorado	<275*	20	Shuster (1980)
northern Utah	394	28	Hennessy (1978)
MEAN	183		
SE	101		

all cases, however. There appears to be general agreement, however, that even though some goshawk nests are found at great distances from water, the presence of water is a desired characteristic (Marshall 1992).

Our survey in the Centennial Mountains of eastern Idaho, while not able to show preferential selection for locations near water, does support the idea that availability of water may be an important factor in goshawk nest site selection. Our study suggests that first order streams and springs with grass forb meadow riparian habitat located in mature conifer forests are an important landscape feature to consider when managing for existing and replacement goshawk nesting areas in the northern and middle Rocky Mountain area. Currently, 4-5% (202,000 ha) of the total wetland area in the Intermountain West is classified as "Palustrine Forested" by the U. S. Fish and Wildlife Service National Wetland Inventory (NWI) (Lee 1989). Western forested wetlands are common in the mountains along low-order streams (Peters 1989) and form an integral part of forest ecosystems (Anthony et al. 1987). In the Rocky Mountain states, average loss rates of the original forested riparian acreage has been estimated to be approximately 1% per year with much greater losses reported in specific areas (Lee 1989). Such estimates indicate the importance of managing riparian habitat not only for goshawks but for other wildlife species which occur in forested areas of the West.

SUMMARY AND RECOMMENDATIONS

We surveyed a large (84.7 km^2), relatively pristine forest area in the Centennial Mountains of northeastern Idaho for nesting goshawks in 1993 using the Kennedy-Stahlecker (1993) broadcast survey method to determine the placement of goshawk nest sites in relation to riparian habitats. Other objectives were to describe the type of water sources and riparian habitats found closest to occupied nest sites, to determine nest density in undisturbed Douglas fir habitat, and to evaluate potential bias in our existing database which consisted of nest locations found opportunistically over the last decade.

We determined using GIS coverages for the study area that 25% of the area fell within 250 m of permanent water sources defined as the near-riparian zone. All nests found (2 occupied and 5 associated alternate nests) fell within this near-riparian buffer zone. Although we could not determine statistical significance due to low sample number of nesting territories found, results suggest that water sources are important in goshawk nest site selection in large tracts of unbroken forest habitat in the Centennial Mountains.

Goshawks nests were found near first order, low gradient streams which originated as springs. One of these streams had not been previously mapped or identified in existing databases. Riparian habitats adjacent to streams varied in width from 3 to 100 m and contained a variety of forbs and grasses associated with wet soils. Douglas fir trees dominated the overstory.

Density of goshawk nesting pairs was low: one pair was found per 30.2 km^2 of suitable habitat or 0.33 pairs per 1000 ha. Two occupied nests found, located 7.5 km apart, produced an average of 1.5 young per nest. Overall, occupancy and productivity of goshawk nesting territories on the Forest was low in 1993 which was attributed to cold, wet spring weather.

Goshawk nests were found in stands of large, mature Douglas fir trees at 2146-2197 m elevation situated away from edges and surrounded by large patches of unbroken forest habitat. Nests were not found in fragmented forest habitats either natural or related to timber harvest activity.

For occupied nest sites, the only habitat variable measured which differed significantly from previously measured nest sites on the Forest was a greater distance to edge (MRPP, $p=0.028$). This suggests that nests found previously (by chance or related to timber sale activities), as might be expected, tended to be located

closer to a forest edge than nests found during a large scale systematic survey. The vegetation and topographic features of previously located nest sites, however, were very similar to sites found during our survey. Our accumulated goshawk nest site database should, thus, be a useful tool in planning future surveys and developing management strategies for the northern goshawk on the TNF and adjacent areas.

Based on results of this study plus previous monitoring and research of the goshawk on the TNF, we conclude with the following management recommendations:

1. Planning for goshawk surveys in proposed management areas should include prior identification of all first and second order streams, springs, and ponds. Such areas should receive high priority especially if survey time is limited. In addition to broadcast vocalization surveys, mature stands with greater than 75% canopy cover on moderate slopes with northerly aspects within 300 m of such features should be searched thoroughly for alternate nests.

2. If occupied or alternate nests are found, buffers of mature forest should be maintained which include both riparian and upland zones. Based on research in northern California (Woodbridge and Detrich 1994) and monitoring of nest sites over the past six years on the TNF, minimum buffer size for nesting areas should be between 100-200 acres (40-81 ha) of relatively undisturbed habitat to maintain consistent use by nesting pairs.

3. Radio tracking studies have shown the importance of mature forest stands for foraging goshawks (Fischer and Murray 1986, Austin 1993, Bright-Smith and Mannan 1994, Hargis 1994). To provide foraging habitat within known or potential goshawk home ranges, buffers of mature forest habitat should also be planned around water sources described in #1 above. Although no specific data exist on optimal buffer size for foraging habitat, we suggest that buffers should be a minimum of 100 m in width to provide adequate cover both for prey and foraging goshawks.

4. Efforts should be made to identify and map existing permanent and intermittent water sources within forest habitat in timber management areas. Our survey suggests that important water sources can be overlooked in large patches of forest habitat and thus be excluded from management prescriptions for such habitats.

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REFERENCES

Anderson, R., and T. Schommer. 1992. Presentation at Goshawk Workshop, Blue Mountain Institute, La Grande, OR. (Jan. 9, 1992).

Anthony, R. G., E.D. Forsman, G.A. Green, G. Witmer, and S. K. Nelson. 1987. Small mammal populations in riparian zones of different-aged coniferous forests. Murrelet 68: 94-102.

Austin, K. K. 1993. Habitat use and home ranges size of breeding northern goshawks in the southern Cascades. M.S. thesis. Oregon State Univ., Corvallis, OR.

Bartelt, P. E. 1977. Management of the American goshawk in the Black Hills National Forest. M.A. thesis. Iowa State Univ.

Bloom, P. H., G. R. Stewart, and B. J. Walton. 1986. The status of the northern goshawk in California, 1981-1983. Calf. Dept. Fish and Game. NTIS, 85-1.

Bright-Smith, D. J. and R. W. Mannan. 1994. Habitat use by breeding male northern goshawks in northern Arizona. Studies in Avian Biology No. 16: 58-65.

Bosakowski, Thomas, Dwight G. Smith, and Robert Speiser. 1992. Status, nesting density, and macrohabitat selection of red-shouldered hawks in northern New Jersey. Wilson Bull. 104 (2): 434-446.

Buchanan, J. B. 1991. Spotted owl nest site characteristics in mixed conifer forests of the eastern Cascade Mountains, Washington. M.S. thesis. Univ. of Washington.

Bull, E. L., and J. E. Hohman. 1994. Breeding biology of northern goshawks in northeastern Oregon. Studies in Avian Biology No. 16: 103-105.

Chaney, E., W. Elmore, and W. S. Platts. 1990. Livestock grazing on western riparian areas. U.S. Environ. Protect. Agency. 45 pp.

Craighead, J. J., F. C. Craighead, Jr. and R. J. Davis. 1963. Rocky Mountain Wildflowers. Houghton Mifflin, Boston.

Crocker-Bedford, D. C., and B. Chaney. 1988. Characteristics of goshawk nesting stands. In R. L. Glinski et al. (eds) Proceedings of the Southwest raptor symposium. Natl. Wildl. Fed. Washington, D.C. pp. 210-217.

Crocker-Bedford, D. C. 1990. Goshawk reproduction and forest management. Wildl. Soc. Bull. 18: 262-269.

Cross, S. P. 1985. Responses of small mammals to forest riparian perturbations. Pages 269-275 in Riparian ecosystems and their management: reconciling conflicting uses. First North American riparian conference; 1985 April 16-18; Tucson, AZ. USDA USFS Gen. Tech. Rep. RM-120. Rocky Mt. Forest and Range Exp. ST. Fort Collins, CO. 523 pp.

Cuplin, P. 1986. Wetland habitat. Pages 225-236 in Cooperrider, A. Y., R. J. Boyd, and H. R. Stuart (eds.). Inventory and monitoring of wildlife habitat. U.S.D.I Bur. Land Manage. Service Center. Denver, CO. xviii.

DeStefano, S., and E. C. Meslow. 1992. Status, distribution, and habitat of Northern Goshawks in eastern Oregon. Oregon Coop. Wildl. Res. Unit. Corvallis, OR.

Douglas, David C., John T. Ratti, R. Alan Black, and J. Richard Alldredge. 1992. Avian habitat associations in riparian zones of Idaho's Centennial Mountains. Wilson Bull. 104 (3): 485-500.

Doyle, A. T. 1990. Use of riparian and upland habitats by small mammals. J. Mamm. 71(1): 14-23.

Fischer, D. L. and J. R. Murphy. 1986. Daily activity patterns and habitat use of coexisting *Accipiter* hawks in Utah. PhD. diss. Brigham Young Univ., Provo, UT.

Hall, P. A. 1984. Characteristics of nesting habitat of goshawks in northwestern California. M.S. thesis. Humboldt State Univ., CA.

Hargis, C. D., C. McCarthy, and R. D. Perloff. 1994. Home ranges and habitats of northern goshawks in eastern California. Studies in Avian Biol. No. 16: 66-74.

Hayward, Gregory D., and Ronald E. Escano. 1991. Goshawk nest-site characteristics in western Montana and northern Idaho. Condor 91: 476-479.

Hennessy, S. P. 1978. Ecological relationships of accipiters in northern Utah--with special emphasis on the effects of human disturbance. M.S., Utah State Univ., Logan, UT.

Herron, G. B., C. A. Mortimore, and M. S. Rawlings. 1985. Nevada raptors: their biology and management. Nevada Dept. Wildl. NTIS, No. 8.

Hitchcock, C. L. and A. Cronquist. 1973. Flora of the Pacific Northwest. Univ. of Washington, Seattle.

Hutto, R. L. 1985. Habitat selection by nonbreeding, migratory land birds. In M. L. Cody (ed), Habitat selection in birds. Academic Press, Orlando, FL. pp. 455-476.

James, F. C. and H. H. Shugart, Jr. 1970. A quantitative method of habitat description. Audubon Field Notes 24(6): 727-736.

Johnsgard, P. A. 1990. Hawks, eagles, and falcons of North America. Smithsonian Institute Press. Washington D. C.

Johnson, R.R. and C. H. Lowe. 1985. On the development of riparian ecology. In R.R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H Hamre (tech. coordinators) Riparian ecosystems and their management: reconciling conflicting uses. USDA Forest Service. Gen. Tech. Rep. RM-120. pp. 112-116.

Joy, S. M., R. T. Reynolds, and D. G. Leslie. 1994. Northern goshawk broadcast surveys: hawk response variables and survey costs. Studies in Avian Biol. No. 16: 24-31.

Kennedy, P. L., and D. W. Stahlecker. 1993. Responsiveness of nesting Northern Goshawks to taped broadcasts of 3 conspecific calls. J. Wildl. Manage. 57: 249-257.

Keppel, G. 1991. Design and Analysis: a researcher's handbook. Prentice Hall. Englewood Cliffs, NJ.

Kostrzewa, A. and R. Kostrzewa. 1990. The relationship of spring and summer weather with density and breeding performance of the buzzard *Buteo buteo*, goshawk *Accipiter gentilis* and kestrel *Falco tinnunculus*. Ibis 132: 550-559.

Krueper, D. J. 1993. Effects of land use practices on western riparian ecosystems. Pages 321-330 in Finch, D. M. and P. W. Stangel (eds.). Status and management of neotropical migratory birds; 1992 Sept. 21-25: Estes Park, CO. Gen Tech. Rep. RM-229. Fort Collins, CO. USDA USFS Rocky Mt. Forest and Range Exp. St. 422pp.

Lee, L. C., T. A. Muir, and R. R. Johnson. 1989. Status of wetland habitats in the western United States. Pages 27-31 in B. G. Pendleton (ed.). Proc. western raptor management symposium and workshop. Nat. Wildl. Fed., Washington, D.C.

Marshall, David B. 1992. Status of the Northern Goshawk in Oregon and Washington. Audubon Society of Portland. Portland, OR.

Markow, S. and W. Fertig. 1993. Report on a general floristic survey of vascular plants of Targhee National Forest and vicinity. Univ. of Wyoming, Laramie. pp 81. (dated May 10, 1993).

McGowan, J. D. 1975. Distribution, density, and productivity of goshawks in interior Alaska. Fed. Aid Wildlife Rest. Project Report W-17-3, 4, 5, 6. Job 10.6R.

Moore, K. R., and C. J. Henny. 1983. Nest site characteristics of three coexisting accipiter hawks in northeastern Oregon. Rap. Res. 17(3): 65-76.

Mosher, J. A., K. Titus, and M. R. Fuller. 1986. Developing a practical model to predict nesting habitat of woodland hawks. In J. Verner, M. L, Morrison, and C. J. Ralph (eds.) Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. Univ. of Wisc. Press, Madison, WI. pp.31-36.

Newton, I. 1979. Population ecology of raptors. Buteo Books. Vermillion, S.D.

Newton, I. 1986. The sparrowhawk. T & A D Poyser Ltd. Calton, Eng.

Ohmart, R. D. 1994 The effects of human-induced changes on the avifauna of western riparian habitats. Studies in Avian Biol. No. 15: 273-285.

Ohmart, R. D. and B. W. Anderson. 1986. Riparian habitat. Pages 169-199 in Cooperrider, A. Y., R. J. Boyd, and H. R. Stuart (eds.). Inventory and monitoring of wildlife habitat. U.S.D.I Bur. Land Manage. Service Center. Denver, CO. xviii.

Palmer, R. S. 1988. Handbook of North American birds, Vol. 4. Yale Univ. Press, New Haven, Conn.

Patla, S. 1991. Northern goshawk monitoring project 1990. Report #2. USDA USFS Targhee Nat For., St. Anthony, ID. 37 pp.

Peters, D. P. 1989. Status of wetland habitats in the western United States. Pages 32-37 in B. G. Pendleton (ed.). Proc. western raptor management symposium and workshop. Nat. Wildl. Fed., Washington, D.C.

Reynolds, R. T. 1983. Management of western coniferous forest habitat for nesting accipiter hawks. USDA Forest Service, Fort Collins, CO. Gen. Tech. Rep. RM-102.

Reynolds, R. 1987. Accipiters. Pages 92-101 in B. G. Pendleton (ed.). Proc. western raptor management symposium and workshop. Nat. Wildl. Fed., Washington, D.C. Nat. Wildf. Fed., Washington, DC.

Reynolds, Richard T., and Howard M. Wight. 1978. Distribution, density, and productivity of accipiter hawks breeding in Oregon. Wilson Bull. 90 (2): 182-196.

Reynolds, R. T., E. C. Meslow, and H. M. Wight. 1982. Nesting habitat of coexisting *Accipiter* in Oregon. J. Wild. Manage. 46: 124-138.

Reynolds, R. T., R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce Jr., G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management recommendations for the Northern Goshawk in the southwestern United States. USDA Forest Service. Gen Tech. Rep. RM-217. Fort Collins, CO.

Shuster, W. C. 1976. Northern goshawk nest site requirements in the Colorado rockies. West. Birds 7: 108-110.

Slauson, W. L., B. S. Cade, and J. D. Richards. 1991. User manual for Blossom statistical software. (Revised Aug. 1994). Midcontinent Ecological Science Center, National Biological Survey. Fort Collins, CO. 59 pp.

Sokol, R. R., and F. J. Rohlf. 1969. Biometry. W. H. Freeman and Company, San Francisco, CA.

Speiser, R., and T. Bosakowski. 1987. Nest site selection by northern goshawks in northern New Jersey and southeastern New York. Condor 89: 387-394.

Steele, R., S. V. Cooper, D. M. Ondov, D. W. Roberts, and R. D. Pfister. 1983. Forest Habitat Types of Eastern Idaho-Western Wyoming. USDA Forest Service. NTIS, INT-144.

Stinson, C. H. 1980. Weather-dependent foraging success and sibling aggression in red-tailed hawks in central Washington. Condor 82: 76-80.

Swanson, F. J., S. V. Gregory, J. R. Sedell, and A. G. Campbell. 1982. Land-water interactions: the riparian zone. Pages 267-291 in R. L. Edmonds (ed.). Analysis of coniferous forest ecosystems in the western United States. US/IBP Synthesis Series 14. Hutchinson Ross Publ. Co., Stroudsburg, PA.

USDI. Fish and Wildlife Service. 1991. Comments on petition to list Northern Goshawk throughout forested west submitted by Charles H. Lobdell, Field Supervisor, Boise Field Office, to Asst. Regional Director, Region 1, U. S. Fish and Wildlife Service, Portland, OR. (Dec. 5. 1991).

Woodbridge, B. and P. J. Detrich. 1994. Territory occupancy and habitat patch size of northern goshawks in the southern Cascades of California. Studies in Avian Biol. No. 16: 83-87.

Youngblood, A. P., W. G. Padgett, and A. H. Winward. 1985. Riparian community type classification of eastern Idaho-western Wyoming. USDA Forest Service Intermountain Region. NTIS, R4-Ecol-85-01.